

# MICROSCALED LIVING BIOELECTRONIC SYSTEMS – COUPLING BEETLES TO SILICON TRANSDUCERS

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Biosensors which take advantage of the extraordinary sensory abilities of highly optimised chemoreceptors are one promising goal in the field of novel sensor developments. Recently, a bioelectronic interface between an insect antenna of the potato beetle (*Leptinotarsa decemlineata* Say) and a field-effect transistor (FET) has been introduced [1,2]. The schematic of this “beetle/chip” sensor is shown in Fig. 1 with the two arrangements of the “whole beetle” and the “isolated antenna” BioFET (biologically sensitive FET).

In order to optimise the sensor performance, it is necessary to characterise each functional part of this biosensor device, i.e. the FET and the antenna with regard to their electronic properties. For the FETs, different gate layouts with different width-to-length ratios such as linear gates, U-shaped gates and meander-like gates have been studied with respect to a high transconductance and signal-to-noise ratio. To understand the signal-generating process inside the antenna, impedance spectroscopy has been performed. An equivalent circuit could be given in order to describe the biological system of the isolated antenna in an electrical way. Typical impedance spectra show that the electrical contribution of the antenna’s impedance mainly originates from its resistive part in the order of about 2 MΩ. The proper combination of both the insect antenna and the FET yields the bioelectronic interface for the highly sensitive and selective odour detection.

As examples, the biosensor characteristics of the potato beetle and the steelblue jewel beetle towards cis-3-hexen-1-ol, guaiacol and 1-octen have been investigated. While cis-3-hexen-1-ol is a marker substance for the detection of plant damages, guaiacol and 1-octen are set free by different kinds of fires, making an early fire alarm possible. To make a separation between the different substances, a BioFET-based sensor system has been developed [3]. Therewith, dose-response curves for the different substances of this beetle/chip sensor could be achieved with lower detection limits down to the ppt concentration range. Greenhouse experiments under real world conditions showed that the detection of single damaged plants within several hundreds of healthy plants

is possible. In this application, the insect antenna of the potato beetle has been favoured. In contrast, by choosing the steelblue jewel beetle’s antenna, the detection of fire-specific odours allows the monitoring of smouldering fires, like burning coal, paper and wood. In this case, the main advantage compared to a semiconductor gas sensor that mainly detects H<sub>2</sub> and CO, is the higher sensitivity in the lower ppb range and selectivity, i.e. the distinction between different fire sources. In order to enable a broader field of applications, a library with different beetle species and their odour detection will be built-up. This reveals possibilities to design autonomous systems on the basis of insect olfaction and insect locomotion.

## REFERENCES

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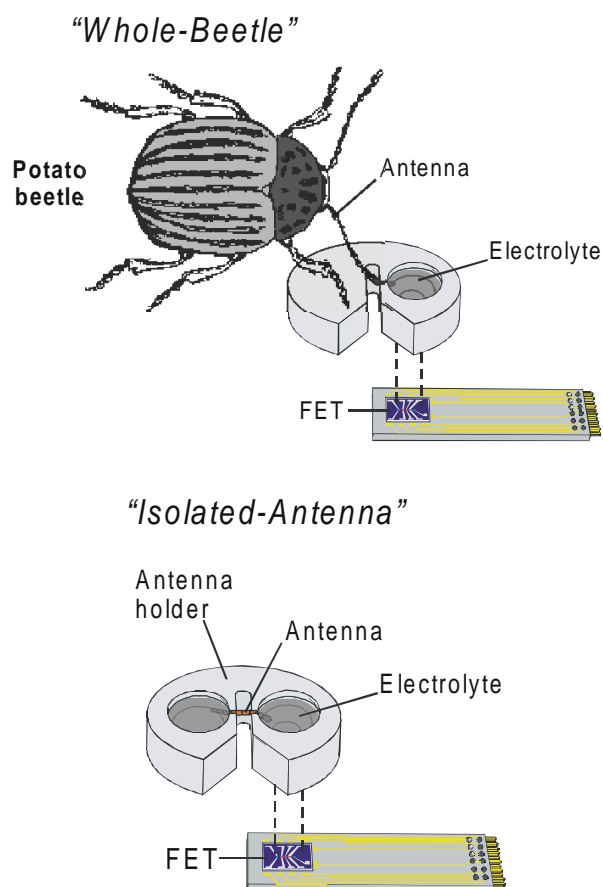


Figure 1. Experimental set-up of the “whole beetle” BioFET and the “isolated antenna” BioFET (schematic).